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# MAP RESEARCH BULLETIN

No. 14

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CENTRAL INTELLIGENCE AGENCY

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# SOVIET MAP PROJECTIONS

## I. Introduction.

Cartographically the North American countries and the USSR have much in common. The combined areas of the United States and Canada, like the Soviet Union, occupy a large territorial expanse that extends over a wide range of longitude and from the middle latitudes to beyond the Arctic Circle. Both areas are faced with the same problem of selecting map projections that will distort neither the size nor shape of the territory. For this reason research on projections for the USSR is of especial significance to the US.

The Russians have established highly competent institutes for geodetic and cartographic training and research and have been working on the theory of projections for many years. No corresponding institutes have been established in the US, and no specialized schools or departments offer a major course of study leading to a degree in geodesy and cartography.

Research on projections has followed a line generally independent of western trends. For small-scale maps of the USSR, emphasis has been placed on the development of minimum-error projections. The most noteworthy products of this effort are the conic equal-interval[1] projections. On the other hand, where specific properties were required, as in the case of large-scale military mapping, standard projections were adopted by Soviet cartographers.

1. This term is a translation of the Soviet ravnopromezhutochnaya, a term used to describe projections on which the parallels are equally spaced.

A. Training and Research in Mathematical Cartography.

The present status of training and research in mathematical cartography is the culmination of a program that began in 1917 in the Moskovskiy Mezhevoy Institut (Moscow Surveying Institute). A special faculty of geodesy was set up to teach the theory of projections and map compilation. By 1922, the faculty developed a special course for geographic-cartographic study. In 1930, the faculty of geodesy became the Moskovskiy Geodezicheskiy Institut (Moscow Geodetic Institute), and, in 1936, became the Moskovskiy Institut Inzhenerov Geodezii Aerofotos'yemki i Kartografii -- MIIGAiK (Moscow Institute of Engineers of Geodesy, Aerial Surveying, and Cartography). At the same time a number of cartographic sections were set up in geographic faculties of various state universities. In 1940, the Novosibirskiy Institut Inzhenerov Geodezii, Aerofotos'yemki i Kartografii (Novosibirsk Institute of Engineers of Geodesy, Aerial Surveying, and Cartography) was founded. These schools not only trained geodesists and cartographers in the theory of projections but also carried on some research on the selection and adaptability of projections for map production.

Research in the mapping agencies of the government may have begun in the early 1920's in the Nauchno-Tekhnicheskiy Sovet (Scientific-Technical Council), an advisory body to the Vyssheye Geodezicheskoye Upravleniye (Supreme Geodetic Administration), which was headed by F. N. Krasovskiy, one of the leading mathematical cartographers in the Soviet Union. Research activity in geodesy and cartography was given added impetus by the founding in 1928 of the Gosudarstvennyy Institut Geodezii i Kartografii (State Institute of Geodesy and Cartography). About 1930, this institute became the Tsentral'nyy Nauchno-Issledovatel'skiy Institut Geodezii, Aerofotos'yemki i Kartografii -- TsNIIGAiK (Central Scientific-Research Institute of Geodesy, Aerial Surveying, and Cartography) and has remained to this day the research organization for the Glavnoye Upravleniye Geodezii i Kartografii pri Sovete Ministrov SSSR (GUGK -- Principal Administration for Geodesy and Cartography under the Council of Ministers, USSR). A special unit was established within the institute for conducting research in mathematical cartography. This unit has carried on research on the selection of projections for maps of the USSR, circumpolar areas and the world. It has also been concerned with the problem of selecting projections for the 1:1,000,000 and 1:500,000 map series. At present, it is preparing a large atlas of projections adapted "for definite cartographic objectives." The institute has also organized a "special brigade on cartometry" to participate on a project set up by the Upravleniye Gosudarstvennogo Geodezicheskogo Nadzora (Administration of State Geodetic Control) to calculate the area of the USSR.

## III. Selection of Pojections for Small- and Medium-Scale Maps.

Up to 1934 the volume of research on the selection of projections was insignificant. Before that date an equal-interval conic projection by De Lisle[1] had been selected for Russian use on small- and medium-scale maps. A number of maps were also compiled on the conformal conic and Bonne projections. In 1922, F. N. Krasovskiy developed a "new" equal-interval projection. Between 1924 and 1927, some research was undertaken on the selection of projections for regional administrative maps. Some of the projections selected show an effort to find a new approach to the study and selection of projections for Soviet cartography.

1. Joseph N. de Lisle, a French astronomer, was invited in 1721 by Peter I to establish a scientific basis for Russian cartography. De Lisle developed a secant conic equal-interval projection for a map of Russia.

Between 1934 and 1938 research on the selection and computation of projections increased markedly. Such work was stimulated in part by the preparations for the publication of the first volume of the Great Soviet Atlas of the World. In spite of the increased research the tendencies among Soviet cartographers to demonstrate their independence of western scientific influences persisted. For example, the Lambert conformal conic projection, which was the most popular projection among Tsarist and early Soviet cartographers, gradually lost favor.

For most maps of the USSR that had formerly been compiled on conformal conic projections, the Kavrayskiy conic equal-interval was adopted. This projection, which was described by V. V. Kavrayskiy in "Matematicheskaya Kartografiya" published in 1934, became the most widely used projection in the USSR.

For the maps in the Great Soviet Atlas of the World, Volume I of which was published in 1935, eleven projections were used. Those used most frequently were the Kavrayskiy conic equal-interval, the Gall cylindrical, and the Eckert sinusoidal equal-area projections. Following the idea of J. Paul Goode's interrupted projections, the Eckert was modified and became known as the Eckert-Goode projection. A Soviet source announced that the Eckert-Goode projection was used for the first time on some maps in the Soviet Atlas. Of the remaining eight projections, only one -- the Lambert azimuthal equal-area -- was used for more than two maps. During the 1934-38 period, M. D. Solov'yev computed another projection, the secant perspective cylindrical, but it was not used until later.

Between 1934 and 1938, the projections most commonly used on maps and in atlases were:

Lambert conformal conic
Kavrayskiy conformal conic
Kavrayskiy conic equal-interval

Krasovskiy "pseudo-conic"
Lambert azimuthal equal-area
Bonne equal-area
Eckert sinusoidal equal-area
Eckert-Goode interrupted sinusoidal equal-area
Mollweide equal-area
Van der Grinten
Gall cylindrical
Solov'yev transverse cylindrical
Azimuthal equidistant (Postel)
Stereographic

After 1938, there appears to have been less experimentation, and fewer types of projections were used. Those in most common use were the Kavrayskiy equal-interval, Solov'yev cylindrical, Lambert equal-area, Krasovskiy equal-interval, and Van der Grinten projections.

Volume II of the Great Soviet Atlas of the World, which is devoted exclusively to the USSR, was published in 1939. Most of the maps -- the general survey as well as most of the economic maps -- were compiles on a conformal conic projection. Three maps, however, were compiled on a conic equal-interval projection; two of these were economic maps. The use of the conformal conic and the conic equal-interval projections for maps showing areal distribution does not follow western cartographic practice.

According to Soviet cartographic literature, guiding principles have been established for the selection of projections for small-and medium-scale maps.

(1) For maps of the world, equal-area projections are to be preferred. Of these, those in most common use are the Mollweide, Aitoff, Eckert, Goode, and interrupted Eckert. Since equal-area projections distort shapes considerably, so-called "arbitrary" projections are recommended if distortion

is excessive for the area mapped. These projections are described as having transitional properties between equal-area and conformal projections. The most popular projections of this category are the Van der Grinten and the Gall cylindrical. Of the conformal projections, the Mercator is described as the one generally preferred.

(2) For maps of hemispheres, the Lambert azimuthal is recommended for equal-area representations, and the stereographic for conformal representations. A highly favored projection in the "arbitrary" category is the azimuthal equidistant (called the Postel projection by the Soviets).

(3) For maps of continents and individual countries, recommended projections include the Lambert azimuthal, the Bonne, and Sanson-Flamsteed for equal-area maps, and the azimuthal equidistant (Postel) for the "arbitrary" projections. No specific advice is given for conformal projections. For maps of the USSR, conic equal-interval, conic conformal, and the Solov'yev perspective cylindrical projections are most widely used.

Since the Soviet Union has not respected the Tsarist signature to the Resolutions of the International Map Committee, its first 1:1,000,000 map did not conform to the specifications of the International Map of the World series. Nevertheless when the new Soviet mapping system was set up, the sheet system of the International Map was adopted as the basic layout for the sheets of all Soviet topographic maps ranging in scale from 1:1,000,000 to 1:10,000. Neither the projection nor the spheroid of reference of the International Map projection, however, was at first adopted. The projection for the first Soviet 1:1,000,000 series was a conic equal-interval projection by Albrecht Penck, with modifications by N.I. Shchetkin. In 1939, a special conference called by GUGK to select a projection for the new or second Soviet 1:1,000,000 series, decided to adopt the modified polyconic projection of the International Map series.

Soviet flight charts in the past have usually been compiled on the Mercator projection. More recently, air-navigation charts have been compiled on secant cylindrical projections.

## IV. Selection of Projections for Large-Scale Maps.

Two projections have been used for Soviet large-scale topographic maps ranging in scale from 1:10,000 to 1:200,000. The Müfling projection, which was adopted first, proved to be suitable for the geographic coordinate system of the Soviet state geodetic scheme. After a few years, however, it was found that the projection was not suitable for translating values from a geographic coordinate system to a rectangular coordinate system, such as is used in civil engineering. Geodetic data obtained in surveys for civil engineering purposes could not readily be translated into topographic surveys if the Müfling projection was used for the plane-table sheets. Consequently, in 1928 the Geodetic Committee of Gosplan (State Planning Commission) decreed that the Gauss-Kruger rectangular coordinate system should be used for plotting all Soviet geodetic data. The Gauss-Krüger transverse cylindrical (transverse Mercator)[1] projection was to be used for all topographic maps of 1:200,000 scale and larger. This projection was devised by K. F. Gauss at the beginning of the nineteenth century. In 1912, L. Krüger, professor at the Potsdam Geodetic Institute, worked out the necessary formulas for translating values from

1. This is the same projection used in the Universal Transverse Mercator Grid system (UTM) recently adopted as the standard large-scale referencing system for the US Army, Air Force, and Navy. In the Soviet Gauss-Krüger system the Central meridians have a scale of unity, whereas in the UTM the scale on the central meridians is reduced one part in 2,500.

the ellipsoid directly to a plane, eliminating the need for determining transitional values for a sphere. A relationship was established between geographic coordinates on the ellipsoid and corresponding rectangular coordinates on a plane. In 1931, V. V. Kavrayskiy published tables for the construction of plane-table sheets and map sheets for the 1:50,000, 1:100,000 and 1:200,000 topographic series for the USSR.

In 1939, the same special conference of GUGK that selected the projection for the new Soviet 1:1,000,000 series also selected the Gauss-Krüger projection for the 1:500,000 series.

## V. Principal Soviet Projections.

### A. The Krasovskiy and Kavrayskiy Projections.

Both Krasovskiy and Kavrayskiy, thinking in terms of the long east-west extent of the USSR, apparently were impressed with the scaling properties offered by a conic projection on which the parallels were equally spaced on all meridians. The basic problem was the selection of the standard parallels that would give the minimum error in both scale and area for a given region. In this way, the two cartographers hoped to obtain a conic projection that would have less linear scale-error than a conic equal-area projection and less error in area than a conformal conic projection.

Krasovskiy worked out his version of such an equal-interval projection by applying the method of least squares to the scale variations on the parallels. According to his calculations, the most satisfactory standard parallels were 39°48'24" N and 73°28'44" N.

Kavrayskiy later found that by retaining the equal spacing of parallels but by choosing 40° N and 70° N as the extreme parallels, he could obtain better results, provided the linear scale along the parallels of extreme scale is inversely proportional to the scale along the parallel of smallest scale.

By taking advantage of the adaptability of conic projections to the middle and high latitudes, the two men felt that they had obtained what might be called "minimum-error" projections. These were obtained, however, at the expense both of equivalency of area and of conformality. It is questionable whether the small linear scale-advantage (about 0.6 percent) of the Kavrayskiy over a Lambert conformal conic for the same area compensates for loss of conformality. No comparative figure is available for the Albers equal-area projection applied to the same area. Since the Albers contains a smaller linear scale-error than the Lambert for comparable areas, the Kavrayskiy projection probably has even less scale-advantage over the Albers projection than over the Lambert.

B. The Solov'yev Projection.

In 1937, M.D. Solov'yev, director of the Faculty of Cartography of the Moscow Institute of Engineers of Geodesy, Aerial Surveying, and Cartography (MIIGAiK), was requested by the Central Scientific Research Institute for Geodesy, Aerial Photography, and Cartography (TsNIIGAiK) to select a projection for the physical map of the USSR for inclusion in an atlas for primary schools. Solov'yev chose an oblique case of the Gall secant cylindrical projection, orienting it to bisect the USSR. He thus obtained a projection which, though lacking any properties of scientific value, had the graphic quality of suggesting the sphericity of the earth by showing the parallels in truer curvature and the meridians in truer convergence than is shown on a conic projection. When used for the USSR, the projection has the specific advantage of giving "a full representation of the huge extent of the Soviet Arctic, including the North Pole." This graphic feature has the propaganda value of showing the Arctic Ocean as a Soviet "Mare Nostrum." On maps of the Soviet Union

..awn on the Solov'yev projection, a prominent boundary ..ymbol, identified as a "Boundary of Polar Possessions of ..e USSR," is extended northward from the standard eastern and western Soviet international boundaries to the North Pole, where a red flag is placed. This device has been used not only ..n all maps of the USSR in the atlas but also on the large ..ysical and political wall maps at 1:5,000,000 published in ..40 and 1941, respectively, and in geography text books.

.. Summary of Soviet Developments.

In the selection and adaptation of projections for Soviet maps, there has been a large amount of experimentation. At first, selections seemed to avoid generally accepted western practices in selecting projections. Later, a trend developed toward the acceptance of some western cartographic practices -- the Gauss-Krüger rectangular coordinate system for large-scale maps, the International Map projection for the new 1:1,000,000 series, and a Lambert conformal conic projection for an excellent 1:4,000,000 set of two maps[1] published by the military mapping authority. So-called Soviet projections, however, are still being used for a number of small-scale individual maps. Strictly speaking, none of the projections devised by Soviet mathematical cartographers is new. The two equal-interval projections are not new but are merely new forms of the Ptolemy and the 18th century De Lisle projection; the Solov'yev cylindrical is an oblique case of the Gall cylindrical projection.

The development of equal-interval projections for the Soviet maps of the USSR is of some academic interest but is of little practical value when specific mathematical properties are required. For example, when conformal projections are required

1. One of these maps has been reproduced in color and is available as CIA 11043.

for navigational purposes, the equal-interval projections are not used even by the Soviets. Their persistent and rather widespread use of the Soviet projections for administrative, general geographic, and atlas maps may be a small segment in the over-all propaganda line to establish a Russian genesis for all scientific achievements. Thus, a leading postwar Soviet text on mathematical cartography credits a 19th century Russian mathematician, P.L. Chebyshev, with proposing a theorem for conformal maps, that "the most suitable projection for the representation of any given part of the earth is that which at its limits preserves scale." The "minimum-error" properties of equal-interval projections meet this specification. The Krasovskiy and Kavrayskiy projections are both based on the minimum-error theorem, but do not fulfill the more scientific element of the theorem, that the projection be conformal.

Conformal conic projections, which in the West are generally considered to be the best conformal projections for the middle and high latitudes, are not much favored by the Soviets, except for large-scale military maps. Whereas the US Air Force uses the conformal conic projection for the middle and high latitudes, the Soviets use a secant cylindrical.

There has been a remarkable lack of Soviet interest in equal-area projections for maps of the USSR. This is all the more amazing because the problem of equivalence in mapping is important in view of the large size and the latitudinal position of the USSR. Particularly noteworthy is the lack of appreciation of the Albers conic equal-area projection, which is considered by western cartographers to be the most suitable for large middle- or high-latitude areas such as the United States and the Soviet Union. The map of the Geologic Map of the United States at 1:2,500,000, published by the US Geological Survey in 1932, uses an Albers projection, but Geologicheskaya Karta SSSR (Geologic Map of the USSR) at the same scale (CIA Call No. 23310) uses an equal-interval projection. This seeming reluctance to use equal-area projections may be explained to some extent by (1) an introversion resulting from the development of the equal-interval projections, whose distortion of equivalency is not great, (2) the emphasis on conformal projections for large-scale military maps, which have received especial attention from Soviet cartographers, and (3) the comparatively small number of maps showing areal distribution, that have been made by the Soviets.

## BRIEF NOTICES

### A. TSETSE DISTRIBUTION MAPS FOR WEST AFRICA.

The distribution of four species of tsetse flies in West Africa is shown by a group of 15 maps that has recently been received by the CIA Map Library from the Directorate of Colonial Survey, London, England. The species included are Glossina palpalis, Glossina longipalis, Glossina morsitans, and Glossina trachinoides. These four species carry the trypanosomes that produce nagana in animals and sleeping sickness in man. On some of the maps, the incidence of sleeping sickness, the year in which it first appeared in the area, and the areas in which the tsetse-resistant Zebu cattle can be kept are also indicated.

The data were collected in the field by Dr. T.A.M. Nash during 1945-46 and were overprinted on bases that show vegetation zones, average annual rainfall zones, or population density. The resulting maps show tsetse distribution in relation to geographic factors.

1. West Africa; 1:5,000,000; Directorate of Colonial Survey; 1948; CIA Call No. 63331. 2 maps. Covers the area south of 14°N and west of 14°E.

2. Map of the Colony and Protectorate of Nigeria; 1:3,000,000; Directorate of Colonial Survey; 1948; CIA Call No. 63332. 4 maps.

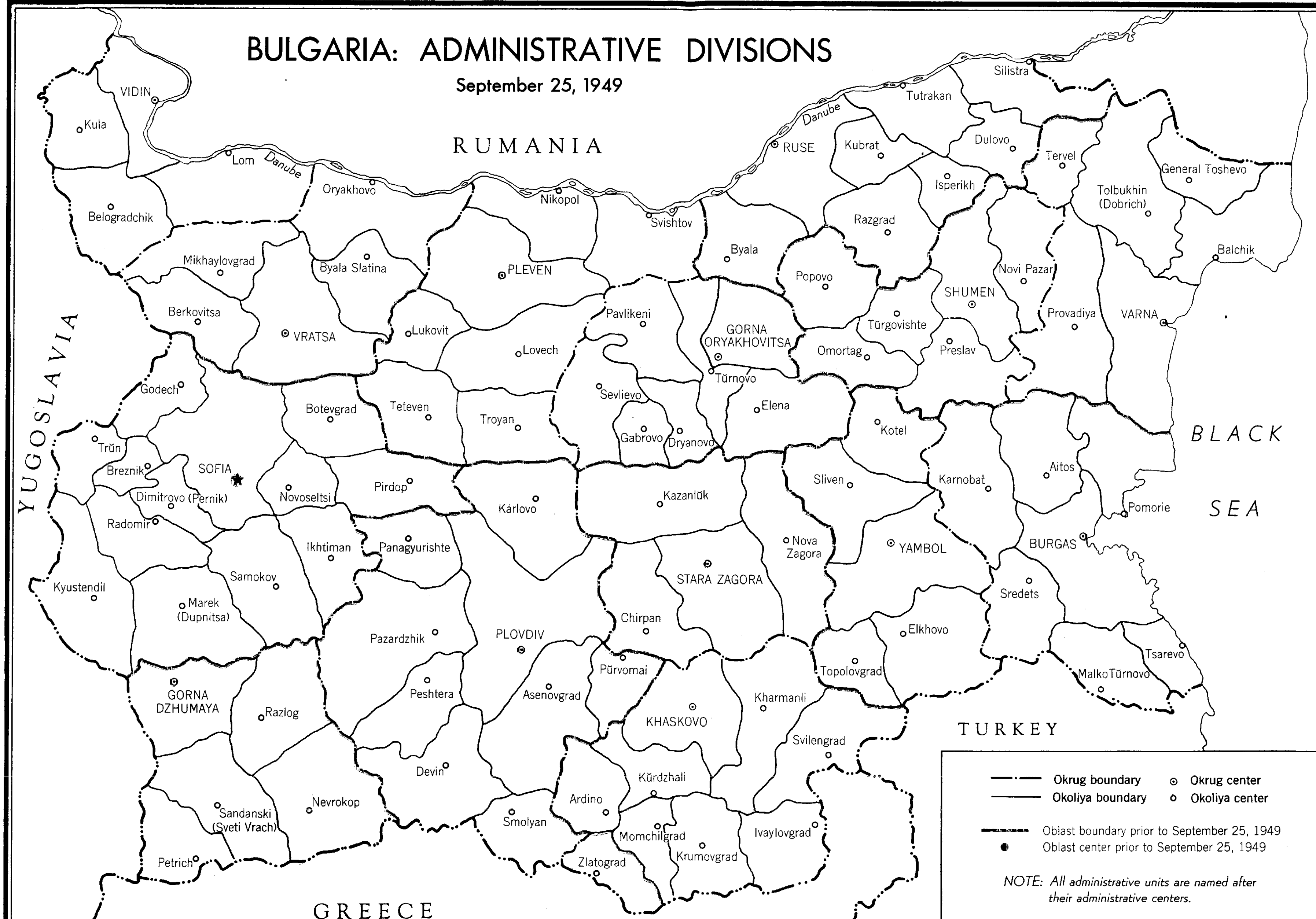
3. Nigeria; 1:16,000; Directorate of Colonial Survey; 1947; CIA Call No. 63350. Only the Zagun region covered.

4. Sierra Leone; 1:1,000,000; Directorate of Colonial Survey; 1947; CIA Call No. 62998. 2 maps.

PROVISIONAL RESTRICTED 11490

# BULGARIA: ADMINISTRATIVE DIVISIONS

## September 25, 1949




SOURCES: *Administrativna Karta na Bulgariya,* 1:400,000; P. Atanasov, 1944
*Predvaritelni Rezultati ot Prebroyavane na Naselenieto na 31 Dekemvri 1946* (Preliminary Results of the Census of Population of December 31, 1946); Sofiya, 1947.
Bulgarian press announcement, September 25, 1949

11490 Map Division, CIA, 3-50 CIA Reproduction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5. Sierra Leone; 1:250,000; Directorate of Colonial Survey; 1947; CIA Call No. 62849. Only the Kissi, Luawa, and Soa regions shown.

6. The Gold Coast; 1:2,000,000; Directorate of Colonial Survey; 1947; CIA Call No. 62999. 4 maps.

7. Tsetse Distribution in the Gambia; 1:500,000; Directorate of Colonial Survey; 1948; CIA Call No. 63330.

B. CHANGE IN BULGARIAN ADMINISTRATIVE UNITS.

On 25 September 1949, the Bulgarian press announced the establishment of a new administrative system. The country is now divided into fourteen okruzi (singular okrug), each subdivided into four to thirteen okolii (singular okoliya).

The new organization apparently does not constitute a major change. The okrug replaces and is closely related to the oblast, which since 1934 had been the first-order administrative unit. Five of the former oblasti -- Burgas, Pleven, Stara Zagora, Varna, and Vratsa -- were divided to form ten okruzi, and four oblasti -- Gorna Dzhumaya, Plovdiv, Ruse, and Sofiya -- have become okruzi almost without change.

In number and name, the okolii correspond exactly with the okolii existing before the reorganization, with one possible exception (Byala is called "Belena" in the press release). Maps are not yet available, however, with which to compare the outlines precisely. The accompanying map (CIA 11490) should be considered a provisional representation of the boundaries until map confirmation is obtained.

The status of the larger towns is not clear. It appears that the city of Sofiya is an administrative entity of the same order as an okrug, separate from the okrug of the same name surrounding the city. Similarly the towns of Burgas, Pleven, Plovdiv, Ruse, Stara Zagora, and Varna are of the same order as okolii and their administration is separate from that of the surrounding area.

## C. ADMINISTRATIVE DIVISIONS OF SYRIA.

The Syrian government increased the number of muhafazat (provinces) from 9 to 12 by Legislative Decrees 30 and 31, dated 30 July 1949. After the coup d'etat of 14 August 1949 the decrees were suspended pending further study, and were finally abolished by Decree 112 dated 11 December 1949. The three short-lived muhafazat of Idlib, Jawlan, and Raqqah are shown at 1:2,650,000 on a base map in CIA map library, Call No. 62843.

Evidence indicates that the name of Jebel Druze muhafazat has been changed to Es Suweida (Soueida), but the change has not yet been confirmed officially.

## D. UNUSUAL PLACE NAME CHANGE IN YUGOSLAVIA.

Present press reports announce that the name of the Yugoslav town of Caribrod (population 3,000) was recently changed to Dimitrovgrad. Caribrod, or Dimitrovgrad, lies in the principal corridor between Yugoslavia and Bulgaria about two-and-one-half miles from the Bulgarian border. Caribrod and its immediate area are Bulgaria irredenta and were integral parts of the Bulgarian state from 1878 to 1919 and again from 1941 to 1945. Dimitrov, the person honored by Yugoslavia, was, of course, the world famous Communist leader and head of the Bulgarian state from 1945 until his death in Moscow in 1949. Were the United States government to change the name of Nome, Alaska, to Trotskyville the situation would be somewhat analagous.

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